Angular dependence of interference effects studied by auger-photoelectron coincidence spectroscopy

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Introduction

In 1994, Vegh and Macek [1] predicted strong interference effects between the emitted electron from innershell photoionization and the subsequent Auger decay. This is due to electron-electron correlation according to the one step model. When both electrons have the same kinetic energy, they become indistinguishable. Since then several experiments have been performed to investigate these effects [2-4] for certain detection angles and energies.

Experiment

To observe these interference effects, the two equal energy electrons have to be detected in coincidence. The interference between the electrons appears in the enhancement or depression of the double photoionization Triple-Differential-Cross-Section (TDCS), depending on the final state, as seen by Selles et al. [4]. A more dramatic interference pattern has been predicted for the case were the photon energy resolution is less than the core hole lifetime width. In the case of the Xe $N_5O_{2,3}O_{2,3}$ Auger decay after $4d_{5/2}$ photoionization, the interference effect for the $^1S_0$ doubly charged final state is destructive, leading to a vanishing TDCS when both electrons are emitted along the polarization vector of the light (see [3]).

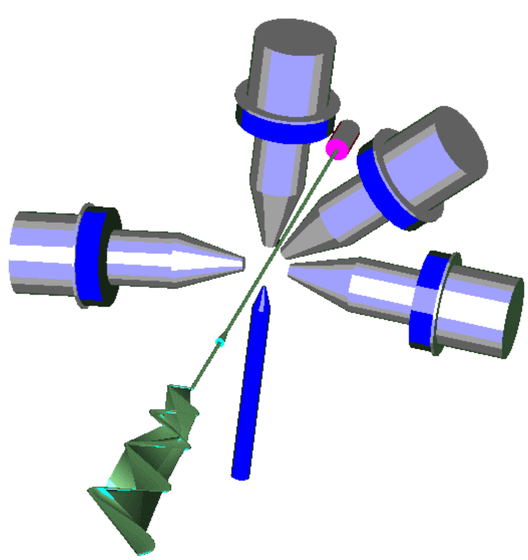

Fig1: Schematic of the experimental setup. 4 analyzer are set in a plane perpendicular to the propagation direction of the light. One Time-of Flight analyzer is independently rotable with respect to the other three, which allows the measurement of the TDCS for all possible angle combinations.

According to Sheinerman et al. [5] the transition amplitude of the TDCS can be described by:

$$T_{fi} = \frac{1}{\sqrt{2}} \sum \left[\frac{M_1(K_A) M_2(k_B)}{(\varepsilon_B - \varepsilon_{aug} + i\frac{\Gamma}{2})} R(A,B) + (-1)^S \frac{M_1(K_B) M_2(k_A)}{(\varepsilon_A - \varepsilon_{aug} + i\frac{\Gamma}{2})} R(B,A) \right] \quad (1)$$

Where $M_1(k_A)$ is the amplitude for innershell photoionization with creation of an electron with momentum k_A and $M_2(k_B)$ is the amplitude for the Auger decay with creation of an electron with momentum k_B; ε_A , ε_B and ε_{aug} are the energies of electron A/B and the auger energy of 27.97eV.
The function R(A,B) describes the Post-Collision-Interaction effect (PCI) between the two electrons.
When $k_A = - k_B$ (same energies and angle $\angle$(A, B)= 180°) then the two terms cancel each other for the $^1S_0$ Xe^{2+} final state. The PCI effect is responsible for an additional disappearance of the Triply-Differential-Cross-Section (TDCS) for small relative angles $\angle$(A,B).

The experiment was performed at the high-resolution beamline 10 of the Advanced Light Source (ALS) in Berkeley. The TDCS was measured with a set of four Time-of-Flight analyzer built at WMU, which are setup such that one analyzer can be rotated independently from the rotation of the other. That allows a measurement of (subsequently) all angles, while keeping one analyzer fixed. The smallest possible $\angle$(A,B) is 35°. The photon resolution was set to 50 meV (Γ=120 mev). The measurement time per angle was 20,000 sec and the "true"- to "random"-coincidence ratio was about 1-2%.

Results

The resultant angular dependence of the TDCS (fig 2) shows a qualitatively good agreement with the predicted data of (1). Due to our restriction in the minimum $\angle$(A,B) we were not able to confirm the disappearance of the TDCS for small relative angle between the two emitted electrons, but it was found by Scherer et al [6].

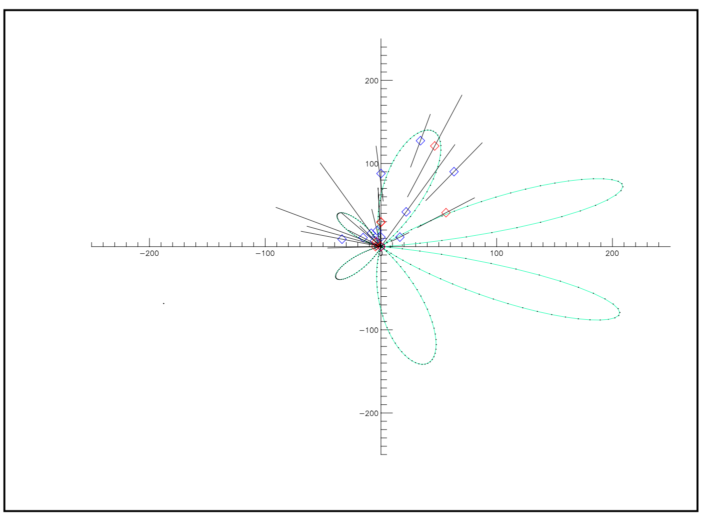

Fig 2: Display of the polar plot of the Triply-Differential-Cross-Section for the $^1S_0$ doubly charged final state of the Xe $N_5O_{2,3}O_{2,3}$ Auger decay after $4d_{5/2}$ photoionization. The minimum at 180 is due to the interference effect. While the minimum at 0 is due to Post-Collision-Interaction (PCI). The dotted line results from equation (1).

Acknowledgments
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